UNIVERSITY OF CALIFORNIA

LAWRENCE RADIATION LABORATORY
BERKELEY, CALIFORNIA 94720

August 15, 1968

Mr. Walter Menaker
69-09 108th Street
Forest Hills, New York 11375

Dear Mr. Menaker:

Thank you for your recent letter concerning my contribution to the CBS program on the Warren Report. I once leafed through a copy of Thompson's book, when I was in the San Francisco Airport bookshop, and I noted that Dr. Thompson did not have a very clear idea of what I had done. But that is not surprising, since Mr. Wyckoff gave a very abbreviated and highly simplified version of my observations, which he repeated independently.

I documented my observations and measurements in two rather long letters to CBS, totalling about 15,000 words. I believe it is typical of the intelligence of the people who write books of the sort Dr. Thompson produced, that they think someone who is experienced enough in the making of physical observations, that he could be a professor of physics at one of the leading institutions in the world, could overlook some blurs in some photographs, particularly when he appears to be the first one who had ever called attention to these blurs, in a substantive way. Of course, I, and Mr. Wyckoff as well, looked at every single photograph that was reproduced in the Warren Report, and not only made detailed measurements of the blurs, but in addition determined in what direction the camera was being traversed during that particular frame. What I did was to measure the length of each blur, which is of course proportional to the angular velocity of the optical axis of the camera system. By looking at the background in the photographs preceding and following that particular blurred photograph, I could tell which way the camera had moved during the blur. As a result of this, I could assign the length of a blur as, for example, plus 3 millimeters, or minus 1.5 millimeters, where the plus or minus signs indicate clockwise or counterclockwise rotation of the camera, as seen from a point above the operator. Naturally, from the point of view of the physicist, I was not interested in the angular velocity of the camera, but rather in the angular acceleration, since Newton's Second Law tells us that the angular acceleration of an object is proportional to the torques acting on it. (The most common version of Newton's Second Law is that the acceleration is proportional to the force, but this is for systems that move in a linear fashion, whereas we are dealing with a camera which is being moved in an angular sense). An angular acceleration is simply the difference in the angular velocities, divided by the time interval between the two measurements of angular velocity. Since the time interval between all successive frames is the same -- about 18.3

seconds, one can get numbers that are proportional to the angular accelerations, simply by subtracting the algebraic numbers that are proportional to the angular velocities. By making this subtraction of angular velocities, including the algebraic sign, I then came up with a table of numbers that was proportional to the angular acceleration of the camera, corresponding to a time midway between each pair of successive frames. I then plotted these angular acceleration values, which could be either plus or minus, as a function of the frame number. The startling thing was that there were three "trains of pulses", each lasting almost exactly one second, with a definite starting pulse, and a definite final pulse. One of these sets of pulses started at Frame 313, confirming the method, and the other two started at Frames whose numbers I can't remember, and since my original letters are at home, I won't bother with them. (Probably they are the frames mentioned by Mr. Wyckoff in his report on CBS television.) The conclusion I drew then, and the one with which Mr. Wyckoff agreed, was that each shot set the neuromuscular system of Mr. Zapruder into oscillation, and it took approximately one second for him to damp out the oscillations. As far as I could tell from the photographs that were shown in the CBS report, Mr. Wyckoff duplicated these trains of oscillatory pulses in his reenactment of the photography sequences. You will remember that there were photographs showing two or three photographers holding Bell and Howell movie cameras, showing that they reacted to the shock wave of a passing bullet, by going into a neuromuscular oscillation, with a recovery time of approximately one second.

I was not able to examine pictures earlier than the first one shown in the Warren Report, but Mr. Wyckoff did go back to the Archives in Washington, and made similar measurements for the Zapruder frames from 1 up to the one first shown in the Warren Report. He showed that although some of the frames did have appreciable blurs, the length of the blurs varied smoothly with frame number;*and simply were a result of the fact that Mr. Zapruder was spraying his camera back and forth like a rank amateur photographer, rather than like the real pro he appeared to be when he settled down to take pictures, when Mr. Kennedy came into view. Incidentally, this observation shows clearly why one should not pay any attention to blurs, but only in the curve showing the difference in blur lengths from ~~print~~ frame to ~~print~~ frame. Mr. Wyckoff then, and correctly I believe, concluded that the oscillatory trains which are visible in the photographs reproduced in the Warren Report were really due to some rather distinctive phenomenon, and not due to the fact that Mr. Zapruder had the hiccups, as District Attorney Garrison commented in his appraisal of the work that Mr. Wyckoff and I did on the films! (In the whole sequence of photographs, the oscillatory pulse trains are concentrated into a narrow time region, including the known time range in which everyone agrees that at least two shots were fired. A physicist would say "the background was

*Because when frame blur lengths in neighboring frames were subtracted, the differences were essentially zero, (the [illegible] [illegible] [illegible] [illegible] on the camera.

The handwritten portion of Alvarez's letter of 15 Aug 68 reads:

> so when ~~frame~~ /sic/ blur lengths in neighboring frames were sub~~x~~tracted, the differences were essentially zero, (no appreciable sudden torque acted on the camera.

handwriting = "so when ~~frame~~ (sic) blur lengths in neighboring frames were subtractea, the differences were essentially zero, (no appreciable sudden torque acted on the camera.

essentially zero".)

I concluded then that three shots, and only three shots were fired, and I pinpointed the times, within a very small fraction of a second, for each shot. In addition to these three very obvious places at which shots were no doubt fired, there was another rather weak set of pulses, about half way between what I labeled as the second shot, and the very obvious third shot that killed the President. This set bothered me for a long time, but I finally came to what I believe is a proper explanation for this weak train. Although the FBI photo interpreters who testified before the Warren Commission, said that there was no way one could tell the accurate position or velocity of the car, when the background was blank (grass), I found two quite separate ways to do this, both of which gave the same value of the car's velocity, and both showed a very sharp change in velocity at just the time that the fourth weak train of oscillatory pulses took place. I puzzled over this for several days, and then I read that at about the time of the last shot, the Secret Service car just behind the President's car turned on its siren. Since no one was very clear about exact times in this extraordinary few seconds, it occurred to me that the siren probably came on just before Mr. Zapruder's weak oscillations started, and just before the driver suddenly slowed down. After all, the men in the Secret Service car had seen the President hit, and it was only natural that they would have pressed the panic button, by starting up the siren. Everyone who has ever driven a car is taught to slow down as soon as he hears a police or fire engine siren, so it is not difficult to imagine that the driver of the President's car immediately let his foot up on the accelerator pedal, when he heard a siren go off twenty-five feet from his car. Actually the hard thing to understand is why the driver of the President's car kept going at exactly a constant rate during at least one, and I believe two shots to the car which he was driving. The only thing that I can think of in this connection is that he was reacting like a circus horse, who goes trotting around a ring, at constant speed, as the acrobats jump up on his back and turn somersaults. I believe that anyone driving the President's car would have let his foot up from the accelerator when he heard a siren like this. So we note that the driver of the President's car actually slowed down abruptly, and did not speed up as he certainly should have done. (Many people have pointed out that if the driver had speeded up and turned rapidly from left to right, the President might have survived the first bullet to hit him, ~~and the~~ last one probably would have missed him.) We must have an explanation of this really extraordinary behavior on the part of the President's driver, which, so far as I can tell, I am the only person to have noticed. I believe that the siren clearly explains it, and of course it would have triggered Mr. Zapruder into oscillation, although probably not as strongly as he was triggered into oscillation by the obvious gun shots. All of these things tie together, and I believe that I did come up with a consistent picture of the whole sequence of events that led to the angular accelerations of Mr. Zapruder's camera, that I measured in a very straightforward way.

I have usually refrained from describing in such detail, the measurements I made, although I have been asked by many people for material of this sort. The main reason that I asked CBS to contract with a research organization of the EG and G type, for which Mr. Wyckoff works, was so that I would not have to spend most of my life writing letters of this sort -- the monkey would be on their back. You can of course send a copy of this letter to Dr. Thompson, but I fear it will do no good -- in his mind I am simply an idiot who could not see some blurs on some photographs that he noticed after I had called attention to the phenomenon, or if I did see them, I did not think they were worth noting.

→ I hope you will not ask me for copies of my two very long letters, which I consider to be personal correspondence with two friends.

I am pleased to see that we have some friends in common, including some high school classmates, whose names I had not thought of in years.

Very sincerely,

Luis W. Alvarez

LWA:am

WALTER MENAKER, M. D.
69-09 108th Street
Forest Hills, N.Y.
11375

September 12, 1968

Professor Luis W. Alvarez
Lawrence Radiation Laboratory
University of California
Berkeley, California 94720

Dear Dr. Alvarez:

Thank you very much for your long and detailed letter of August 15, which I have read several times.

Before I send a copy of your letter on to Dr. Josiah Thompson, you may wish to make a slight correction. On page 2, line 11, you speak of Frame 313 (which is the famous one showing Kennedy receiving the final and fatal shot) when you mean Frame 318, which I have verified from the mimeographed copy of Mr. Wyckoff's statements on the CBS program. The others he cites are 190 and 227. So I enclose your letter for you or your secretary to correct on line 11 of page 2.

I wish I knew the exact distance of Mr. Zapruder from the 6th floor window of the Book Depository and his distance from the assassin postulated behind the grassy knoll. Better yet would be a re-enactment of the crime with guns fired from these positions at a target in the position of the President's car, while someone (preferably Zapruder himself, as his reaction-time is being measured) stood where Zapruder was at the time of the assassination. I suspect that a shot fired from the grassy knoll area might result in a blurring of the frames of film earlier than the shot from the Depository (even though the shot from the Depository occurred earlier). Precise timing would be imperative. And that is what makes me doubt that two assassins, separated by about 100 yards and not visible to eachother (nor in radio communication), could fire within 0.1 second of eachother, which is what Thompson is postulating.

Looking forward to the receipt of page 2 of your corrected letter and again thanking you for the pains you have taken, I am

Gratefully yours,

Walter Menaker, M.D.

Dear Dr. Menaker:
There is no change to
make — I am not in
any way responsible for
Mr. Wyckoff's statements.
Sincerely
Luis W. Alvarez

UNIVERSITY OF CALIFORNIA

LAWRENCE RADIATION LABORATORY
BERKELEY, CALIFORNIA 94720

September 20, 1968

Mr. Walter Menaker
60-[illegible] 108th Street
Forest Hills, New York 11375

Dear Mr. Menaker:

When I took your letter home to file with my material concerning the assassination of President Kennedy, I pulled out a couple of the graphs, and brought them in to the laboratory so that I could duplicate them and send them to you for your own use and so that you could send one of them to Dr. Josiah Thompson.

The first chart shows the angular acceleration of the optical axis of Mr. Zapruder's camera, as a function of frame number, reading down in five separate graphs. I'll make a few comments on notations and marks on the chart. First of all you will see that the three main trains of acceleration impulses last for almost exactly one second each. In addition to the three one-second long trains on the first, second and fifth lines, there is the shorter and less intense train starting about 290 that I explained to my own satisfaction, and told you about in my last letter. On the middle line, there are two pulses that are just "out of the noise". By this I mean that there were two photographs where I thought that points were slightly spread out, and I listed these as minimum signals. These are responsible for the two little indications of a back and forth acceleration of the line of sight. (I would like to stress that the data that I show is all original raw data, and I never did anything to smooth out any data, or go back and remove points that I thought had significance on the first survey. Therefore the two noise pulses on the middle line are just at the minimum detectable limit, and since there is always noise in any measurement, I don't think they have to be treated seriously.) I am sorry that I do not have the first 170 frames available, but as I said in my letter, Dr. Wyckoff did measure these, and found that there were no appreciable acceleration pulses, although there were of course streaks due to a high angular velocity of the camera during Mr. Zapruder's enthusiastic panning. (Subtraction of the streak length in neighboring frames gives differences too small to measure.)

On the right-hand column, it says "camera turns cwld", which is physics shorthand for clockwise looking down. Which means that the initial motion of Mr. Zapruder's camera was such as to move the optical axis of his camera suddenly towards the right, and then back to the left. This motion occurred in frame 313, and is of the proper sign to be caused by the shock wave from the bullet, which passed very close to the camera on the way to the automobile. I believe that this "first motion" was a direct interaction of the shock wave on the camera, and did not involve Mr. Zapruder's neuromuscular reaction. Of course that reaction can be seen very strongly in the next few frames, but it is my belief that the first reaction was occasioned by the shock pressure acting on the camera itself. This same pressure is of course what breaks windows when a supersonic airplane flies overhead. (In the earlier shots, the bullet didn't pass so close to the camera and was therefore not strong enough to cause this direct interaction.)

The two circles on the first and second lines are my best guess as to when the shot was fired -- about 1/3 of a second before Mr. Zapruder's neuromuscular system went into oscillations. There is much in the literature that says that the response time of the human neuromuscular system is a third of a second, and therefore it seems reasonable that the first reaction would come about a third of a second after the system had been stimulated. (You will note that the pulses are about one third of a second apart.) For this reason, my best guess as to the times of the three shots are approximately 177, 217, and of course 313.

I have never checked to see what Mr. Wyckoff said, until this very moment, when I looked at your letter again. I see you say that he quotes 190 and 227, which of course are different than my best guesses. (Let me remind you again that the reason I asked CBS to get someone like Mr. Wyckoff to do the job, was so that I wouldn't be spending the rest of my life writing letters explaining why I thought it was one frame number while somebody else thought it was another. I still like the numbers I selected better than the ones Dr. Wyckoff did, but please let's not get into an argument about this.)

The Warren Commission, according to the notation I made on the chart, said that the shot that they could identify came somewhere in the range of frames 206 to 225. As far as I can tell this came largely from an examination of Mr. Kennedy's reaction in putting his hand to his throat. I think it is interesting that my suggestion that it happened at frame 217 comes almost halfway between the two limits set by the Warren Commission report.

Before I leave this figure, I should say that I believe it could be reproduced by anyone who took the trouble to examine and measure the photographs reproduced in volumes that were appended to the Warren Report. I should say that I started out measuring each streak with a fine scale and a pair of dividers, but after I had gone about halfway through the frames, I concluded that I could do just about as well by looking at the streaks and assigning them an estimated value between 1 and 5, together of course with the algebraic sign saying which way the acceleration moved the camera axis. I mention this only to say that a remeasurement might change the magnitudes of the accelerations, but it would certainly not change their signs, nor change the frame numbers at which they occurred. I did the measurements as well as I could, and as I said earlier I never changed any numbers, and I certainly did not go back and repeat the measurements. For this reason, I may have made a mistake or two, but I do not think that the general pattern of the trains of acceleration pulses can be changed by further measurements. Certainly it does absolutely no good to use a microscope or a magnifying glass, since the pictures available are all half tones, and one can actually see better without a magnifying glass under those conditions.

The second figure shows the position of the car relative to the background, from frames 260 to 340. I was most interested to read the details of the testimony by the FBI photo interpretation expert, who said that it was absolutely impossible to tell where the car was in this period, since there were no marks on the background against which to make the measurements. If you look at these pictures, you will see that there was a shiny piece of metal or glass on the grass, and this reflected light directly from the sun into Mr. Zapruder's camera. As a result of this, there is a streak in the background which one can use as a perfect reference mark, and measure the position of the car certainly better than ± 4 inches, in real space. The curve shows that the car was going at a very uniform speed very near to 12 miles an hour, from frame 260 to about frame 300, and after that it again went at a very constant speed, but closer to 8 miles per hour. All of the points on this graph are again original data, with no smoothing of any sort. The fact that the line goes through practically the center of each point indicates the extreme accuracy of the measurements. At an average of about 10 miles an hour, the car moved about 15 feet per second, or close to 1 foot per frame. The very small scatter of the points will convince you that I knew exactly where the car was during this whole period, and that the sudden change in the velocity was a real thing, and that it should be explained in some way.

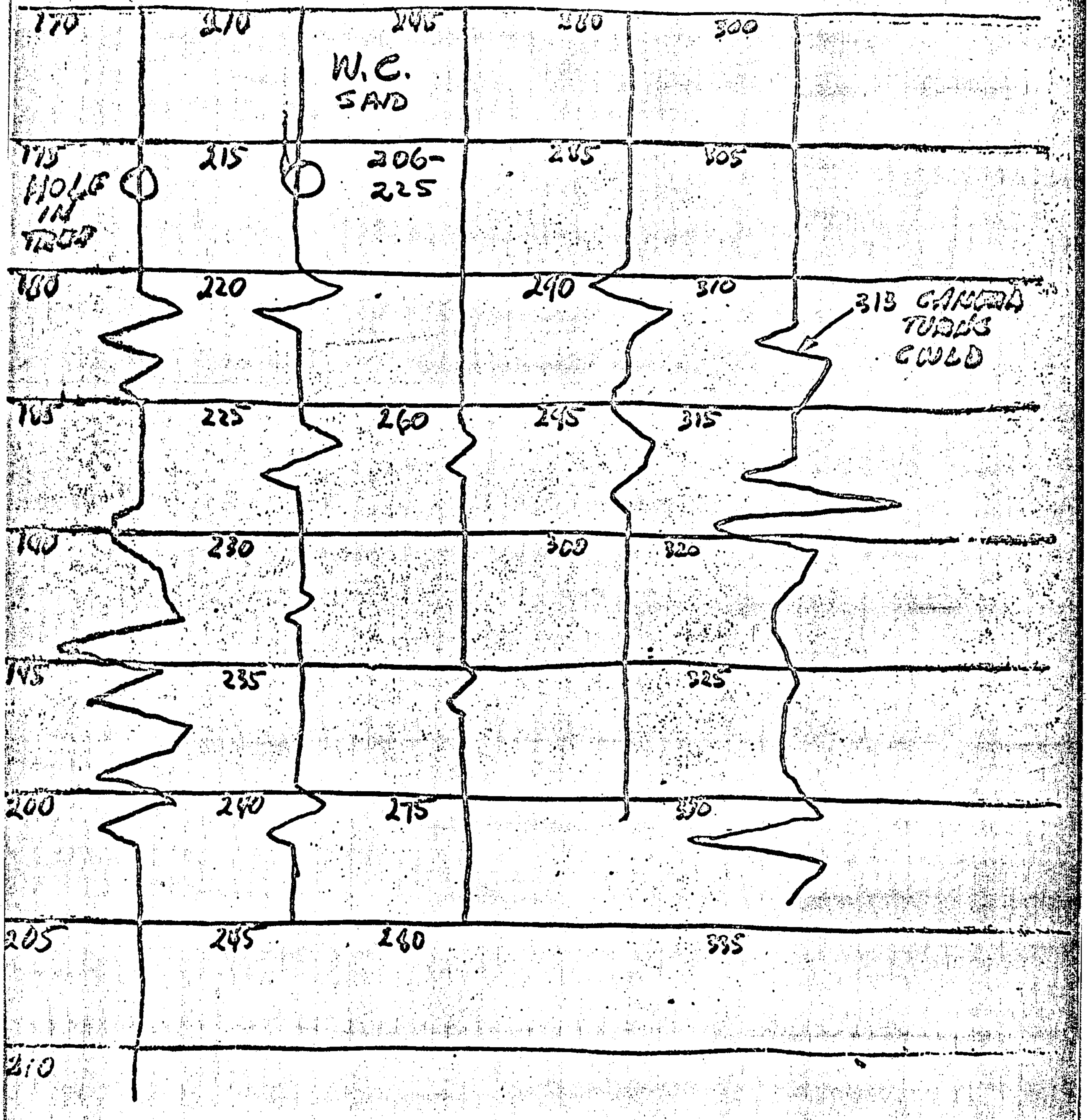
In addition to the two curves that I show here, I made a number of others, one of which showed quite conclusively that the camera was not running at 24 frames per second, as Mr. Zapruder was at one time quoted as saying. It took me several weeks to find a "clock", that would let me make such a statement unequivocally. From the point of view of the physics of the investigation I made, I got more personal satisfaction out of that discovery than out of anything else, since it took a good deal of observation and analytical experience, to make the deduction. I don't believe that anyone seriously questions the camera speed any more, so it can simply remain a bit of personally satisfying detective work that I did on that matter.

I have just reread your letter, and am really quite astounded that you would think I would change my letter to agree with something that Mr. Wyckoff said. Once a scientist comes to believe that he should only publish things that are the consensus of the measurements of all of his scientific associates or competitors, he stops being a scientist. Unfortunately I am finding that many of my young associates feel that they should never publish anything until they have telephoned to all of the people they know who are doing similar experiments in this country and abroad, to see if they are "getting the right answer". I am intensely opposed to this way of doing science, and that is why I reacted so strongly to your suggestion that I change something that I stated with some conviction in my letter. (Of course anyone can make typographical errors, and had you pointed out such an error, I would have been happy to change it. But the thought that I should change my personal conclusion because it disagrees with something Mr. Wyckoff said, is absolutely shocking to me.)

Very sincerely,

Luis W. Alvarez

LWA:am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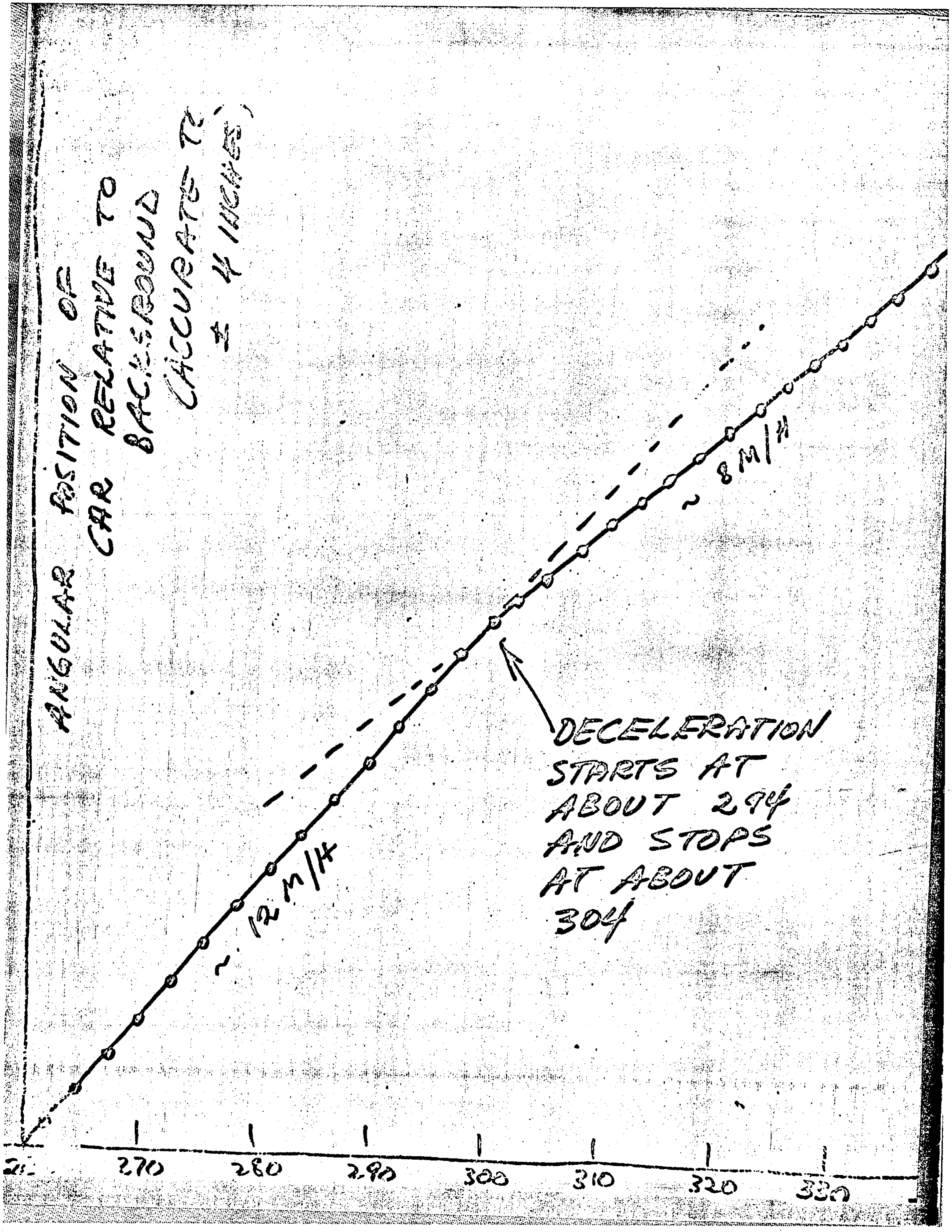

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